Construction Analysis for Pavement Rehabilitation Strategies

Tutorial Training Workshop

Spring 2006

Dr. E.B. Lee

University of California at Berkeley

Institute of Transportation Studies

Introduction - Who We Are

- Questionnaires: Pre-evaluation
- Sign-up Sheet, Name Tag, Course binder/CD
- Introduction: Name, Background, Office
- CA4PRS Research Project since 1998
- Sponsored by SPTC: State Pavement Technology Consortium (CA/FL/MN/TX/WA) - FHWA Pooled-fund Program
- Leader - Caltrans HQ Design and DRI (Division of Research)
- Hands-on Tutorial Training : Project Level
- Metropolitan Districts: D3, D4, D7, D8, D12

Course Outline & Contacts

- **Course Binder Overview + Installation**
- **Web Information Source**
- http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm
  http://onramp.dot.ca.gov/newtech/offices/materials_and_infrastructure/rmi_branch/
- **Michael Samadian: HQ DRI**
  - **Tel: 916-324-2048**
  - **Michael_M_Samadian@dot.ca.gov**
- **Dr. E.B. Lee: UCB - ITS**
  - Tel: 510-665-3637
  - eblee@berkeley.edu,
  - http://www.ce.berkeley.edu/~eblee/

Course Schedule -Day 1

8:30 – 9:00 a.m.	Course Introduction
9:00 – 9:50 a.m.	*CA4PRS* Overview Presentation
9:50 – 10: 00 a.m.	AM Break 1
10:00 – 11:00 a.m.	Tutorial 1: PCC (Concrete I)
11:00 – 11:10 a.m.	AM Break 2
11:10 – 12:00 p.m.	Tutorial 2: PCC (Concrete II)
12:00 – 1:00 p.m.	Lunch
1:00 – 2:00 p.m.	Tutorial 3: CSOL (AC Overlay)
2:00 – 2:10 p.m.	PM Break 1
2:10 – 3:00 p.m.	Tutorial 4: FDAC (Full-depth AC)
3:00 – 3:10 p.m.	PM Break 2
3:10 – 4:20 p.m.	LLPRS Pilot Projects
4:20 – 4:30 p.m.	Day 1 Wrap up

Course Schedule - Day 2

9:00 – 10: 15 a.m.	Lab Exercise 1: PCC Projects
10:15 – 10: 30 a.m.	AM Break
10:30 – 12:00 p.m.	Lab Exercise 2: AC Projects
12:00 – 1:00 p.m.	Lunch
1:00 – 2:15 p.m.	Lab Exercise 3: District Projects
2:15 – 2:30 p.m.	PM Break
2:30 – 3:45 p.m.	Design-Construction-Traffic: Integrated Analysis
3:45 – 4:00 p.m.	Course Evaluation and Closing

CA4PRS Model Overview

- Development Background
- Modeling Structure
- Analysis Process
- Input & Output Interfaces
- Implementation Projects
- Tech Transfer Efforts
- Discussion

Pavement Failure

30 to 50 year old pavements require maintenance and rehabilitation at shorter and shorter intervals.

Maintenance and rehabilitation are less effective when underlying structure reaches advanced deterioration.

Caltrans Long-life Pavement Rehabilitation: LLPRS

- Deterioration of Aging Pavement : Built in '50s-'70s
- 75% traffic growth and 4% mileage expansion (last 20 years)
- Adverse Effects on Quality, Safety, Costs
- Long-life Pavement Rehabilitation Strategies
  - To rebuild 2,500 lane-km of segments among 78,000 lane-km
  - Candidate projects are mostly PCC pavements in the LA & SF
  - Criteria: Poor structural and ride quality => 150,000 (???) Average Daily Traffic (ADT) or 10% Trucks
- LLPRS Objectives and Practice: Get-in, get-out, stay-out
  - Provide 30-40 years of design-life with minimum maintenance
  - Accelerated fast-track construction
  - Minimizing CWZ impact on traffic delay and local business

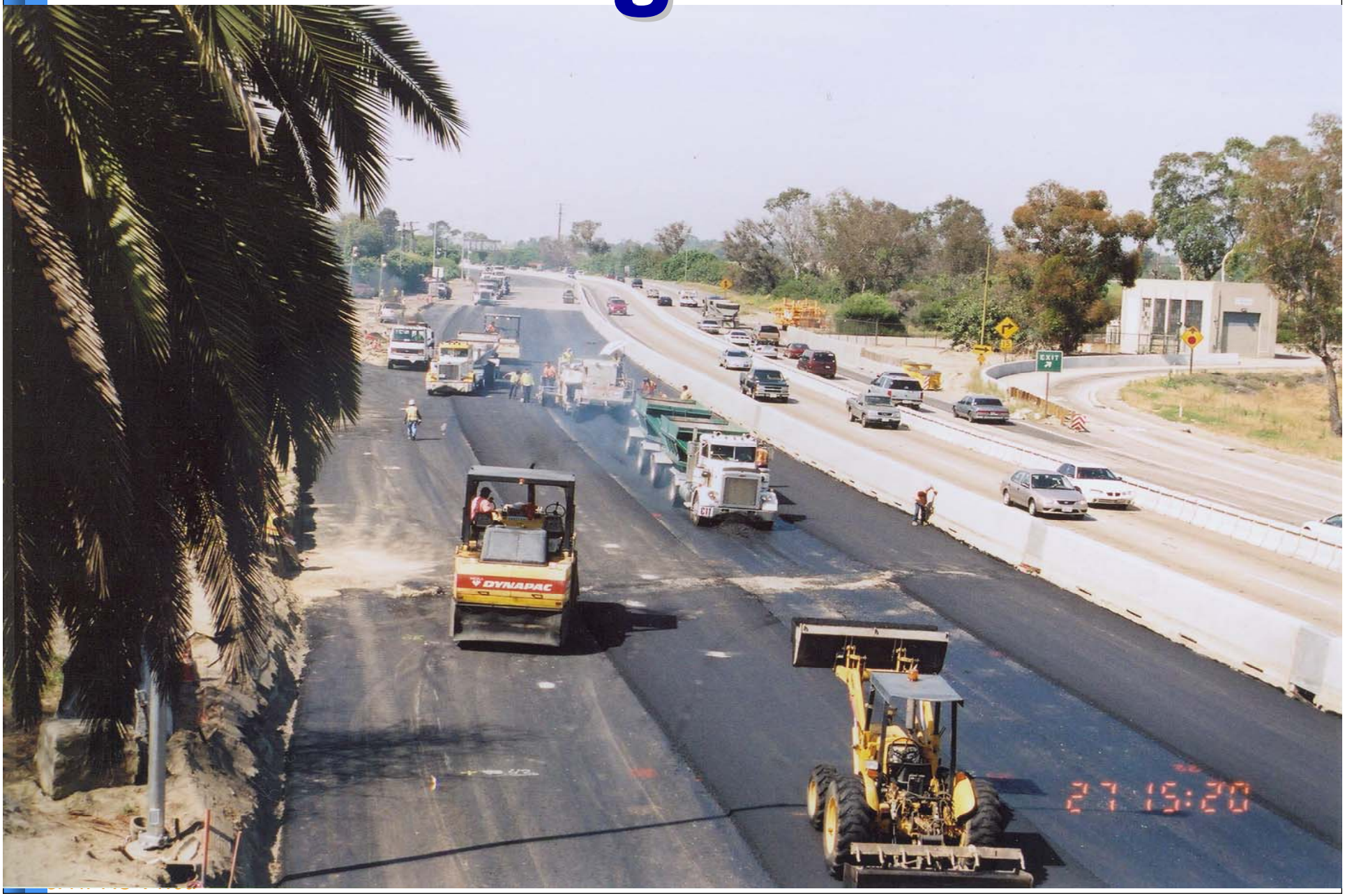
CA4PRS Capability and Platform

- **Mission**
  - Decision support tool for LLPRS projects
  - Integrates design, construction, and traffic analyses to balance competing objectives: Long-life Pavement with Fast-track Construction and Minimum Traffic Disruptions
- **Analysis Features**
  - Estimates optimized schedule (duration) of rehabilitation
  - Check traffic impact (Road user cost and queue delay)
- **System Platform**
  - MS Windows application
  - Stand-alone or Network-server
  - Platform: Access database with Visual Basic 6.0
  - Stores historical reference data from case studies

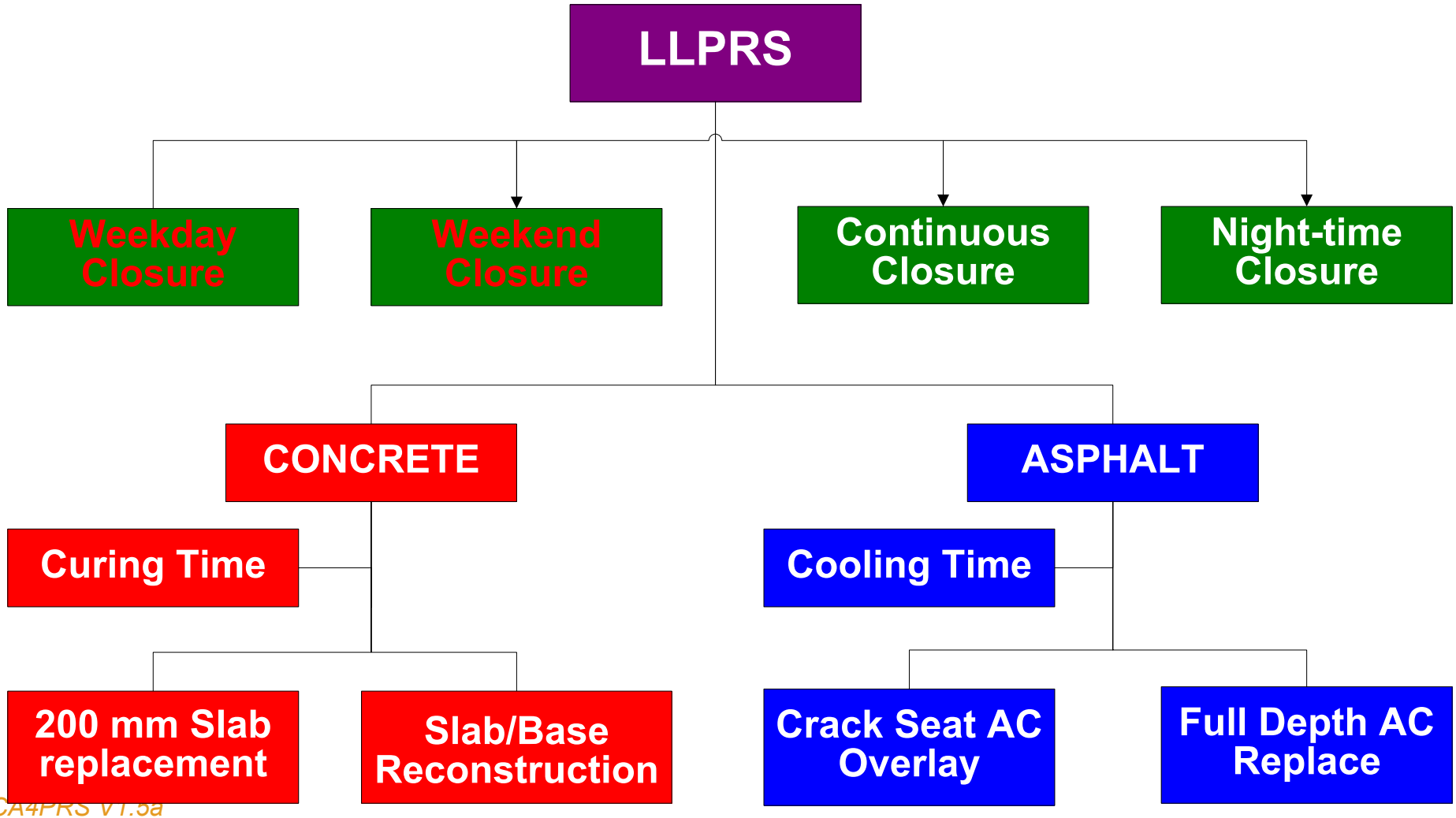
Where Can CA4PRS be Used in a Rehab Project?

- Planning: Pre-construction Evaluation
  - "What-if" rehabilitation scenarios
  - Value Analysis Tool => PSSR
- Design: Construction & Traffic Management Plans
  - Construction-staging plan
  - CPM schedule and contingency plan
  - "A+B (working days)" and Incentives contract
  - Supplement PS&E Package
- Construction: Contractor's work plan
  - Improve constructability constraints
  - Assess the request of contract change orders

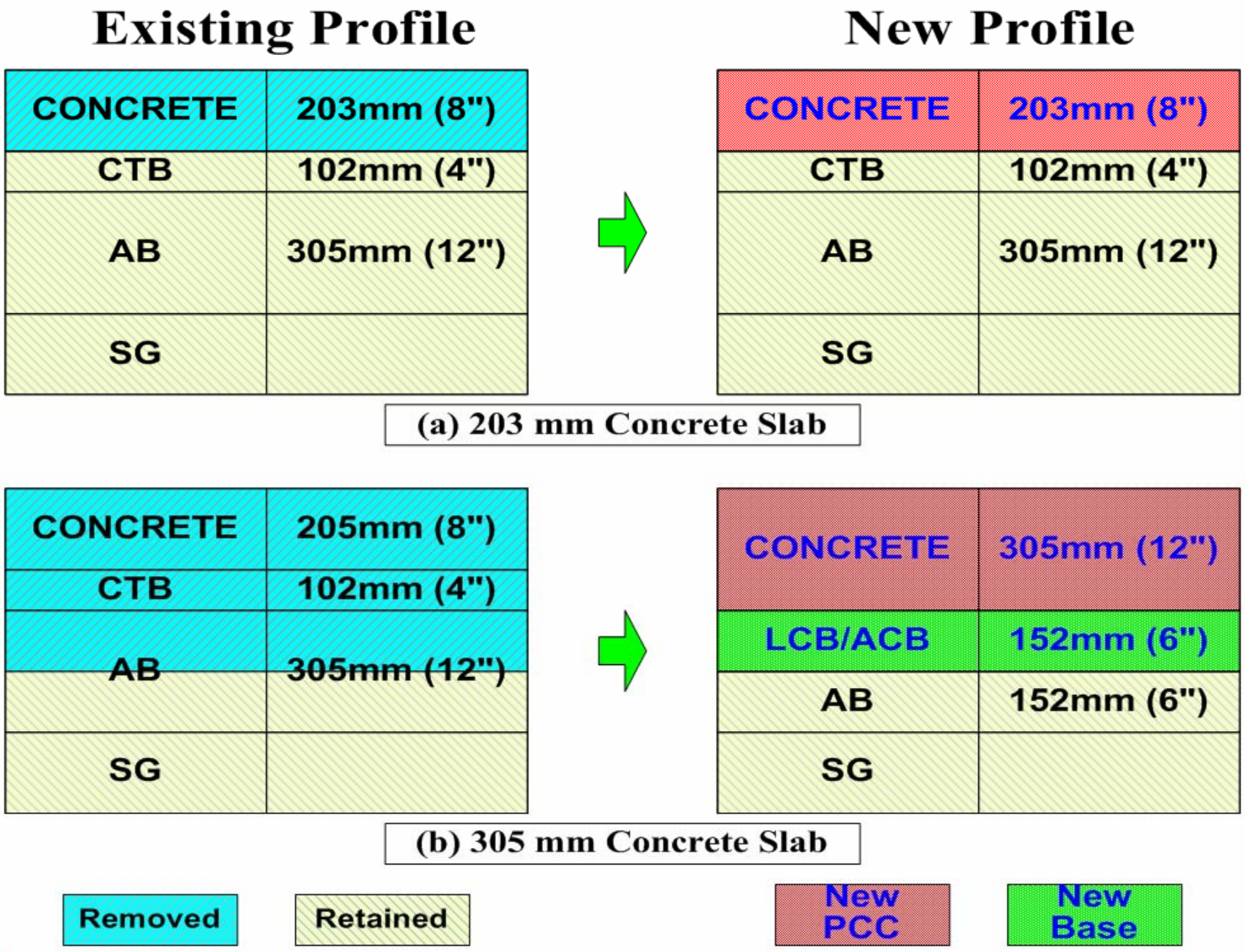
Modeling Structure



Concrete Reconstruction: PCC
Crack-Seat AC Overlay: CSOL
Full-depth AC Replacement: FDAC

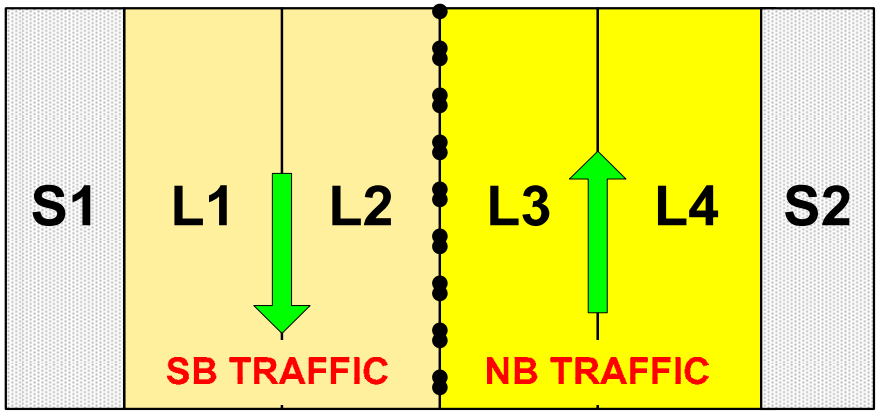


Typical Caltrans Concrete LLPRS Cross-section Changes

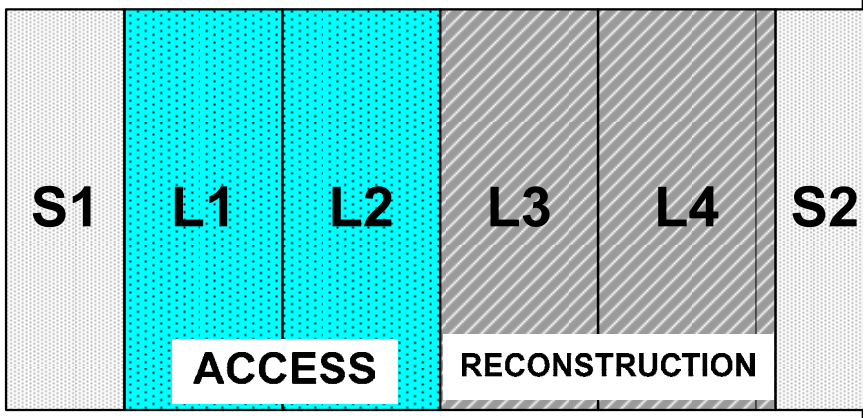


Full Closure (Counter-flow Traffic)

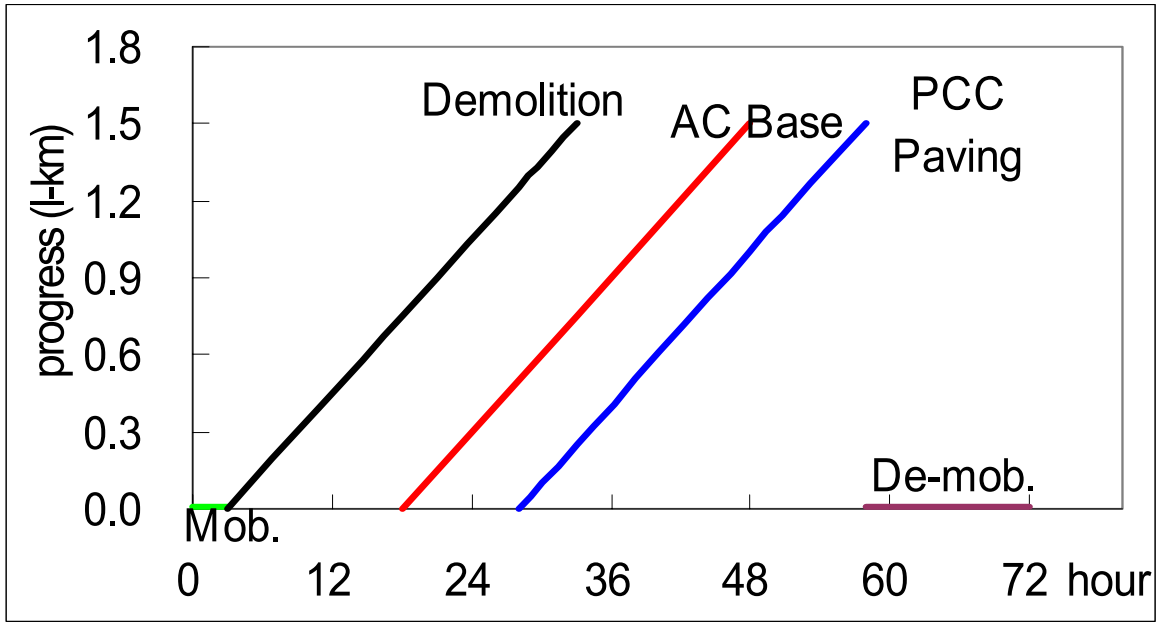
PCC Concurrent Double-lane Rehabilitation



Traffic Roadbed

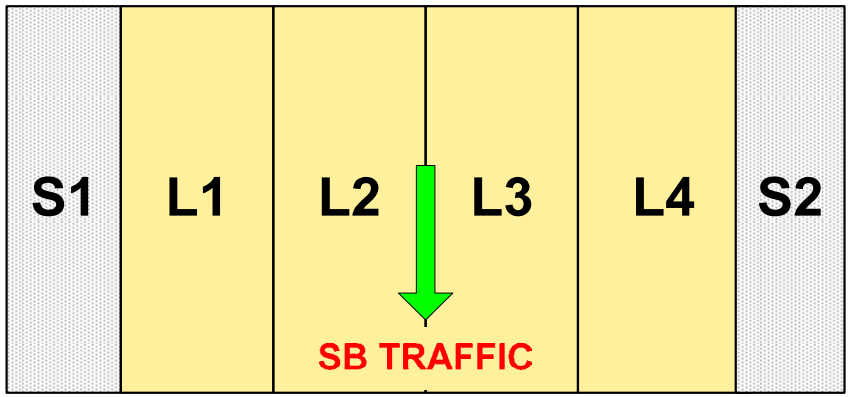


Construction Roadbed

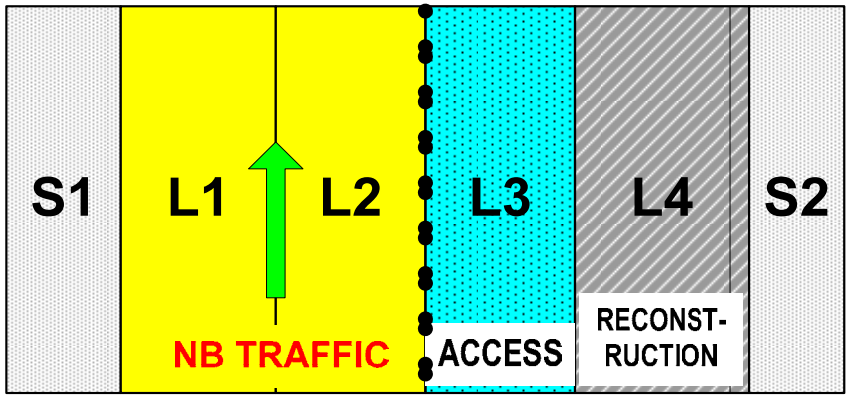


Half or Partial Closure

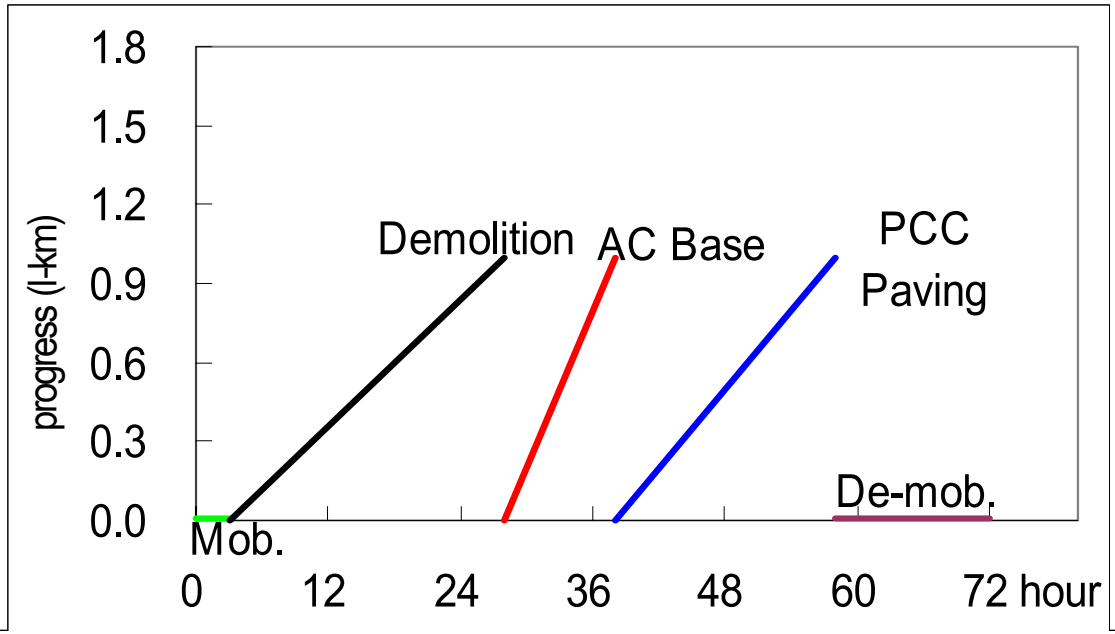
PCC Sequential Single-lane Rehabilitation



Traffic Roadbed

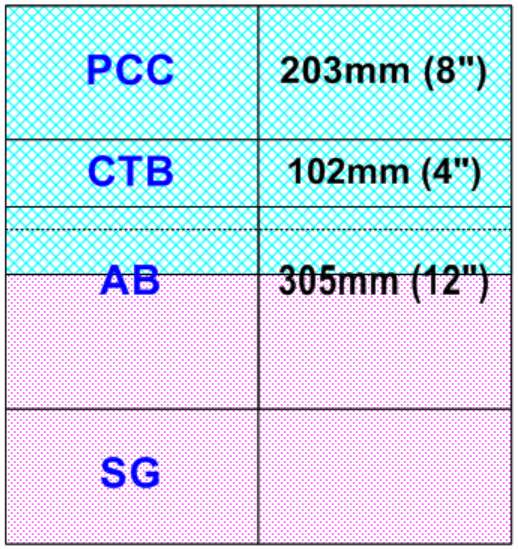


Construction Roadbed



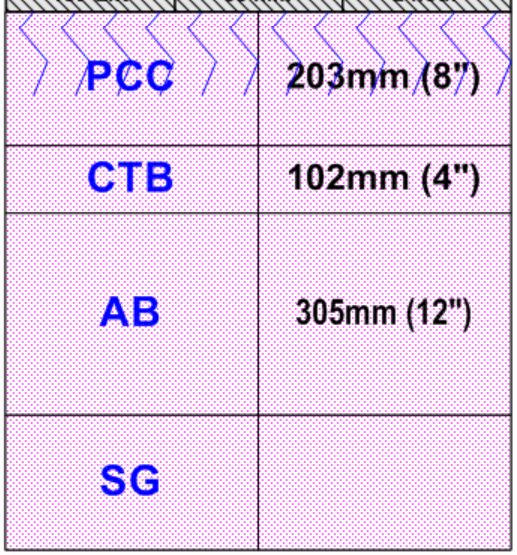
Typical Asphalt LLPRS Cross Section (CSOL and Full-depth AC)

Existing Pavement



Crack-seat & AC Overlay

Total thick. = 230 mm (9")		
Layer	Thick.	Cooling
Final Lift	25 mm	0.5 hour
3rd Lift	75 mm	4 hour
2nd Lift	75 mm	4 hour
1st Lift	55 mm	2 hour



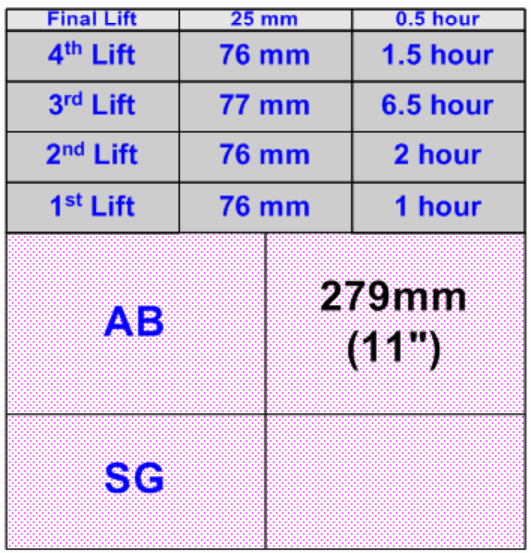
Retained Fabric

AC(CSOL)

OR

Full-Depth AC replacement

Total thick.=330mm (13")		
Layer	Thick.	Cooling
Final Lift	25 mm	0.5 hour
4th Lift	76 mm	1.5 hour
3rd Lift	77 mm	6.5 hour
2nd Lift	76 mm	2 hour
1st Lift	76 mm	1 hour



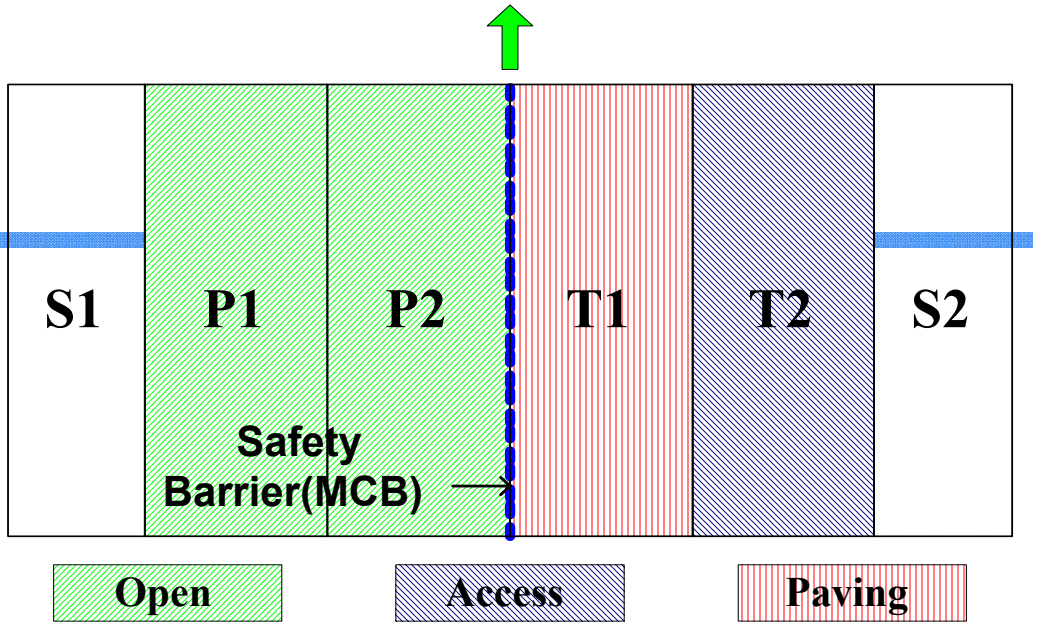
Removed Retained AC

Lane Closures (CSOL)

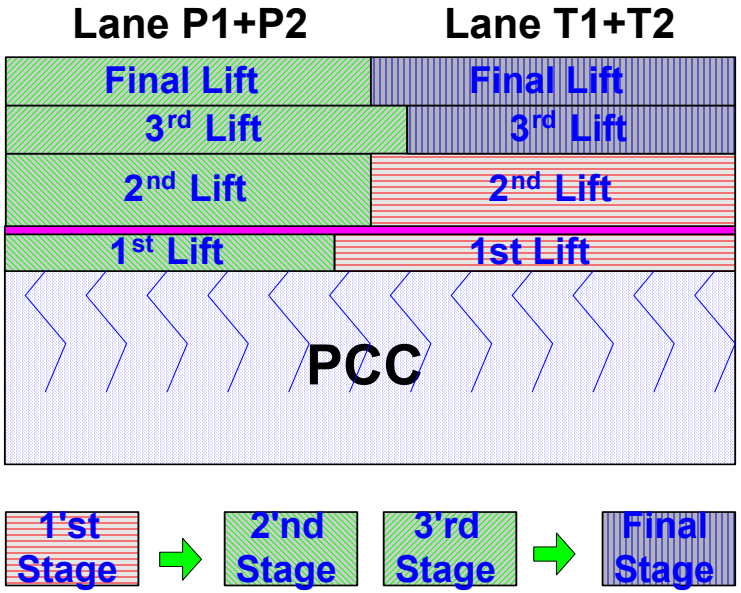
1. Full Closure + Full Completion

2. Half Closure + Full Completion

3. Half Closure + Partial Completion



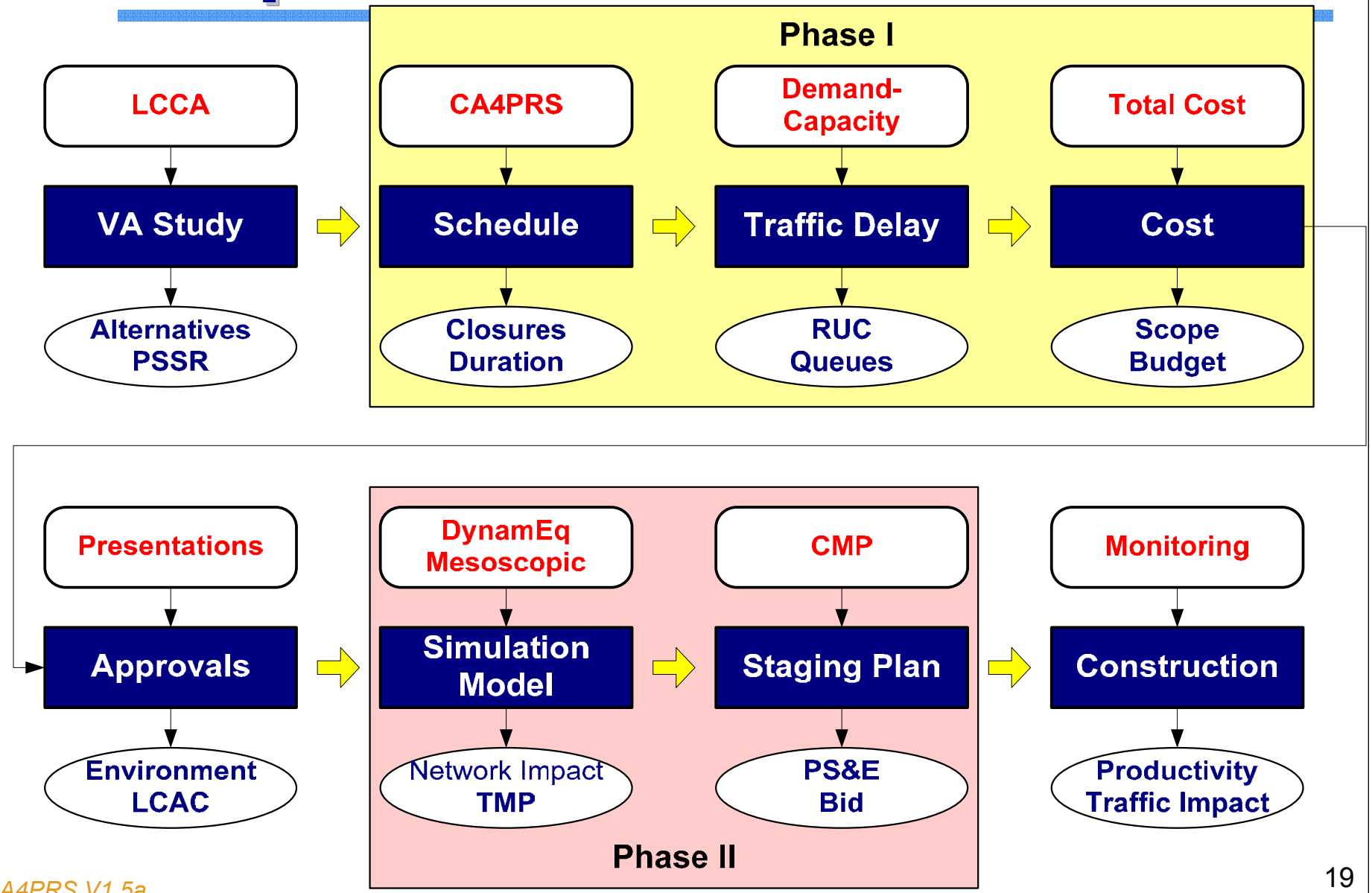
(a) Plan View (1'st stage)



(b) Sequence of Paving

Analysis Process

Framework for CA4PRS Implementation on LLPRS



Step 1: *CA4PRS* Production and Schedule Analysis

- **Input 1: Pavement Design**
  - Rehabilitation strategy alternatives
  - cross-section and materials alternatives
- **Input 2: Traffic Control & Operations**
  - Construction widows (Closure timing)
  - Lane closure alternatives
- **Input 3: Construction Constraints**
  - Activity lead-lag time relationships
  - Construction resources logistics
  - Weather (AC Cooling time, PCC curing time)
- ***CA4PRS* Outputs**
  - Maximum rehabilitation production (lane-km)
  - Total closures and project duration
  - Parameters sensitivity

Step 2: Traffic Delay Analysis
Road User Cost + Maximum Delay

- **Incorporated Traffic Analysis Tools**
  - Highway Capacity Manual (Spreadsheet)
  - Macro Simulation: FREQ
  - Microscopic Simulation: Paramics
- **Needed Additional Traffic Information**
  - Geometry
  - Demand
  - Capacity
  - Traffic Demand Control
- **Traffic Analysis Outputs**
  - Total Road User Cost (RUC)
  - Maximum Delay per Closure
  - Demand Sensitivity

Step 3: Economic Analysis

Total Cost = Agency + Road User Costs

- **Comparison of Alternative Scenarios**
  - Select the Most Economical Rehabilitation Scenarios
- **Total Cost: Economic Analysis**
  - Total cost = RUC + Agency cost
  - Agency Cost = Construction + Traffic Handling
  - Apply a Discount Factor for Road User Cost
- **Other Qualitative Aspects**
  - Pavement Life Expectancy: LCCA
  - Environmental Aspects
  - Public Perception
  - Impact on Local Business

Step 4: Economic Analysis

Total Cost = Agency + Road User Costs

- **Comparison of Alternative Scenarios**
  - Select the Most Economical Rehabilitation Scenarios
- **Total Cost: Economic Analysis**
  - Total cost = RUC + Agency cost
  - Agency Cost = Construction + Traffic Handling
  - Apply a Discount Factor for Road User Cost
- **Other Qualitative Aspects**
  - Pavement Life Expectancy: LCCA
  - Environmental Aspects
  - Public Perception
  - Impact on Local Business

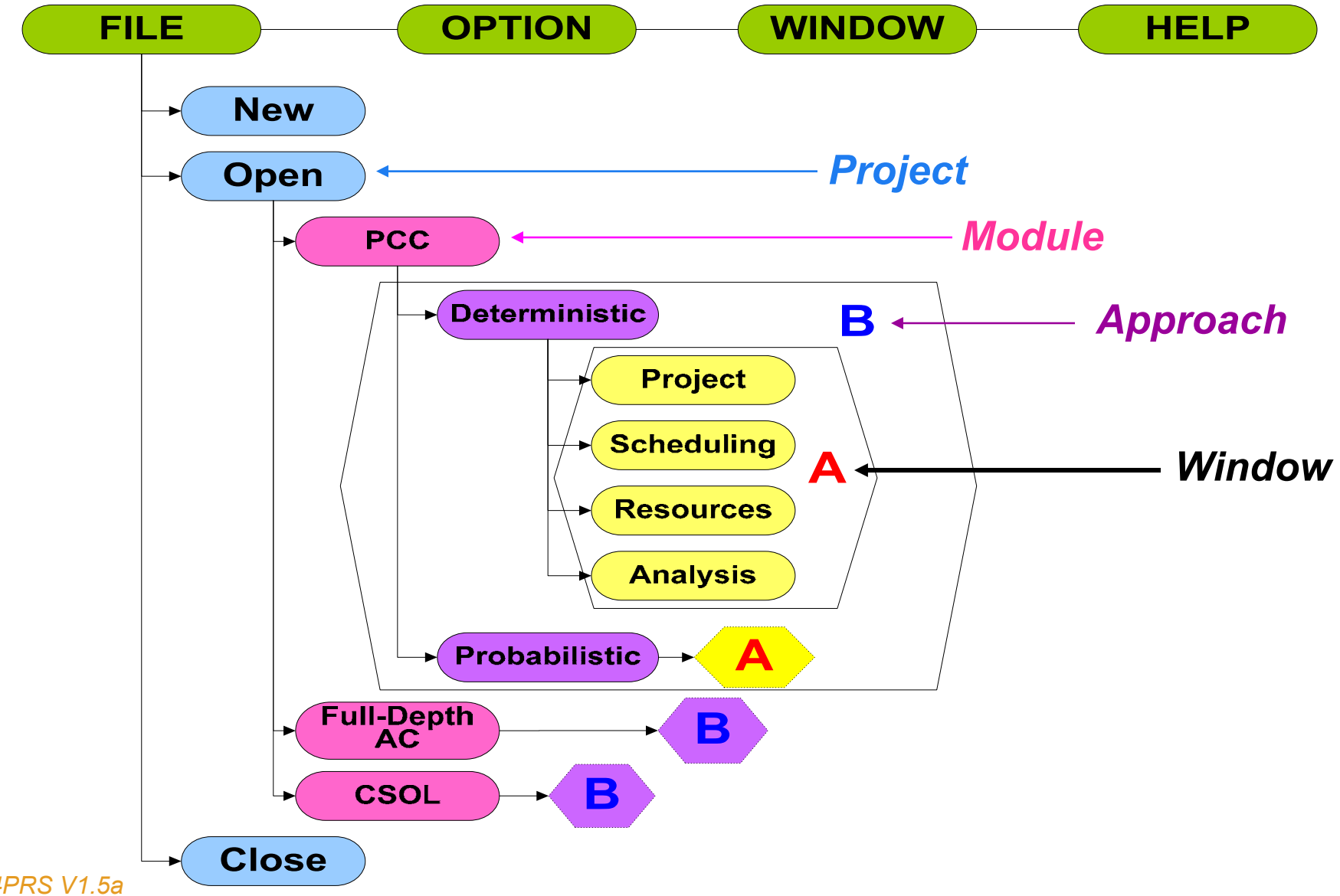
Step 5: Preferred Scenario

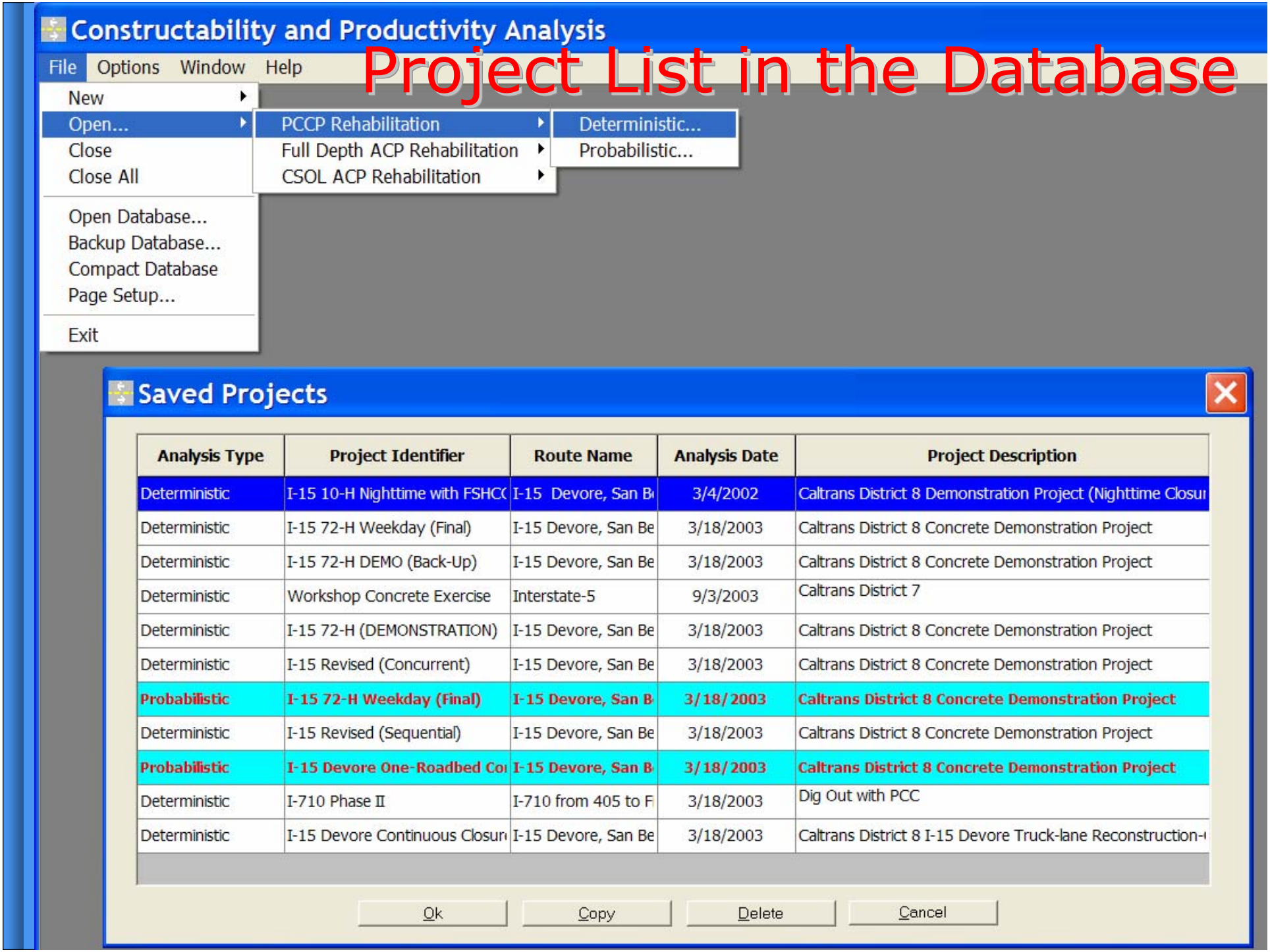
Construction & Traffic Management Plans

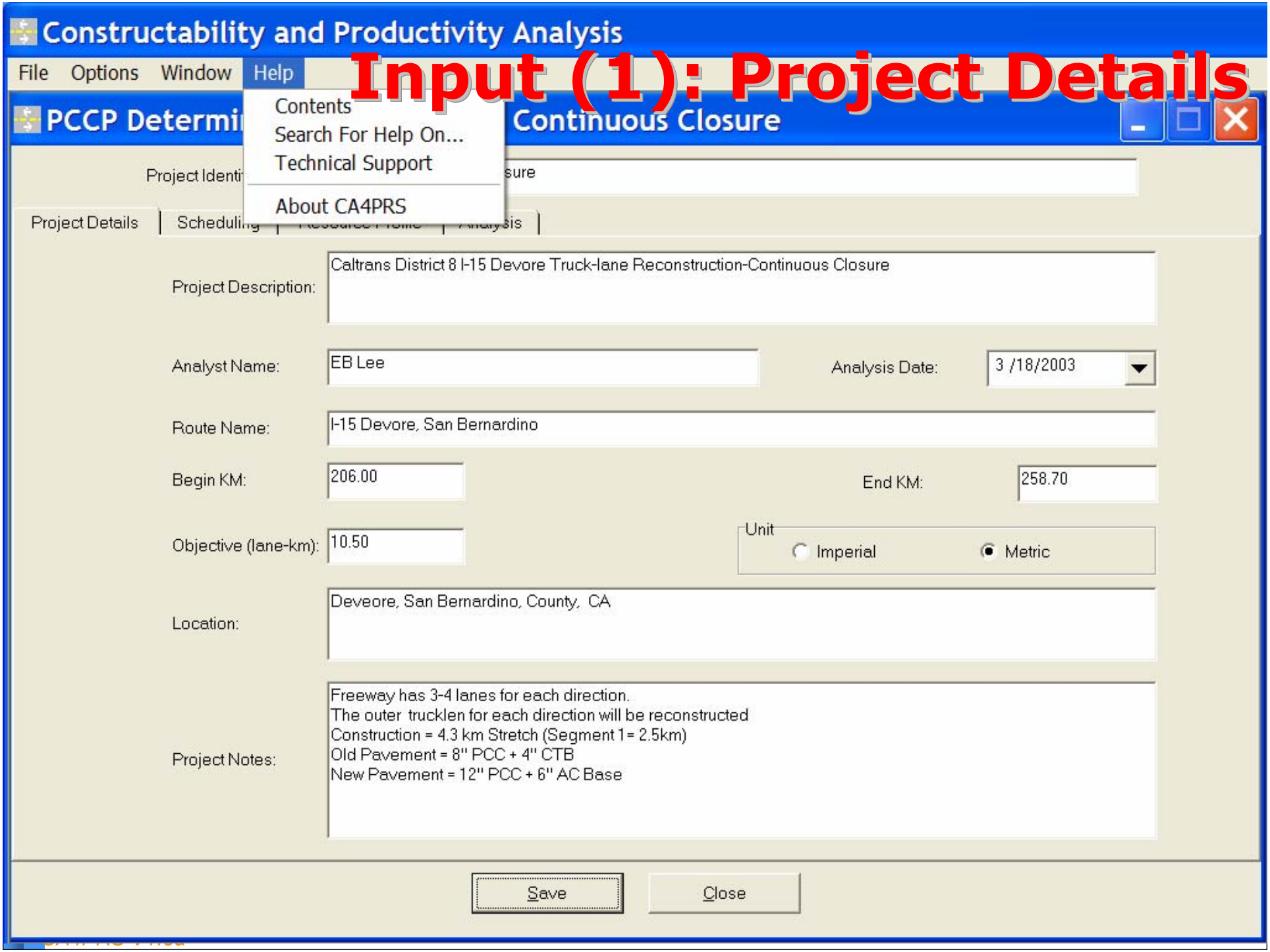
- **Construction Management Plan**
  - Rehabilitation Scope and Process
  - CPM Schedule
  - Contingency Plan
  - Incentives and “A + B” (Cost/Schedule) Contract
- **Traffic Management Plan**
  - Automatic Workzone Information Systems
  - Detour Plans
  - Public Outreach: Demand Reduction
  - Lane Closure Charts: Lane, Ramp, Connector
- **Implement Public Outreach**

Input & Output Interfaces

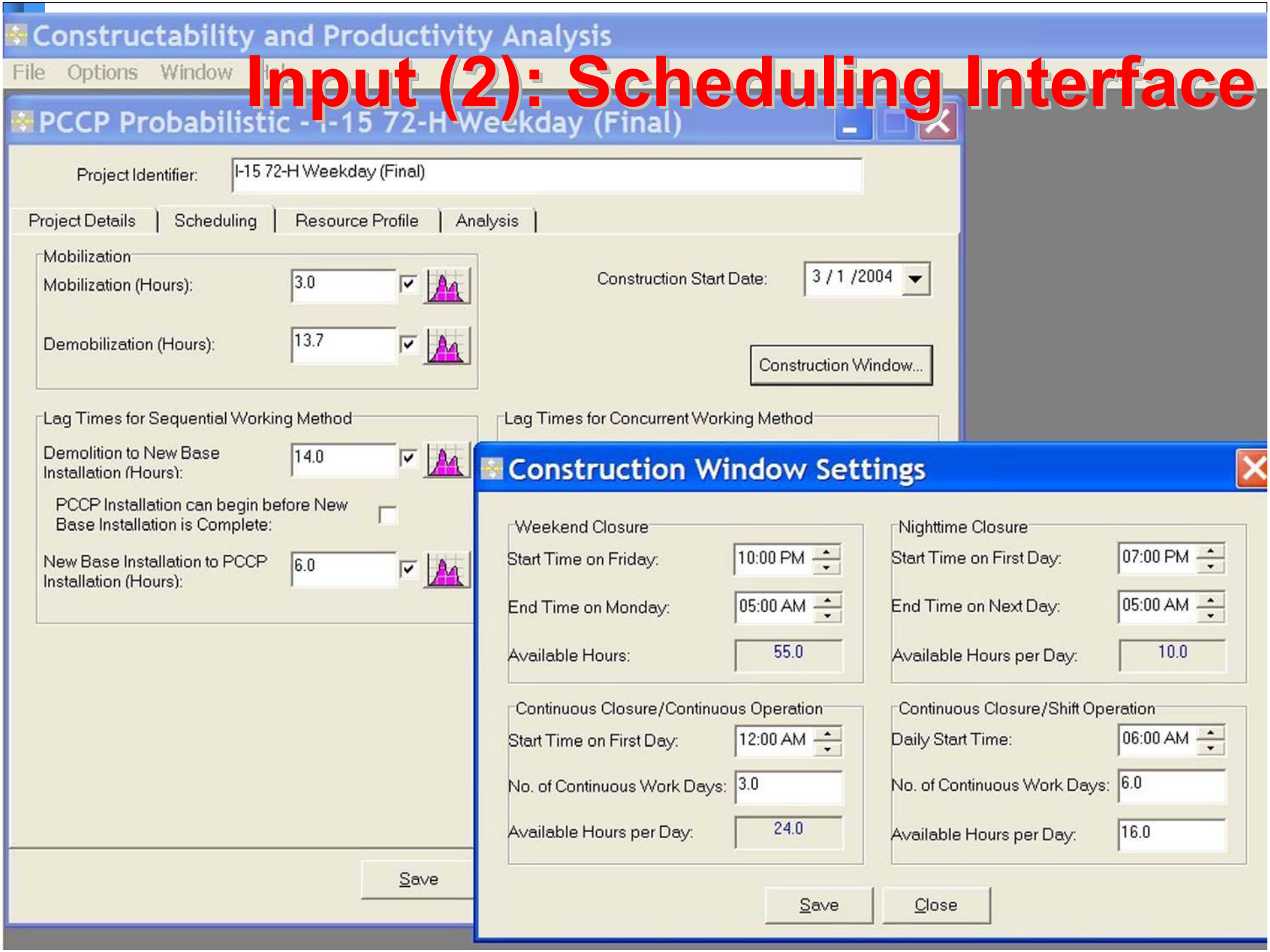
CA4PRS Software Menu Tree



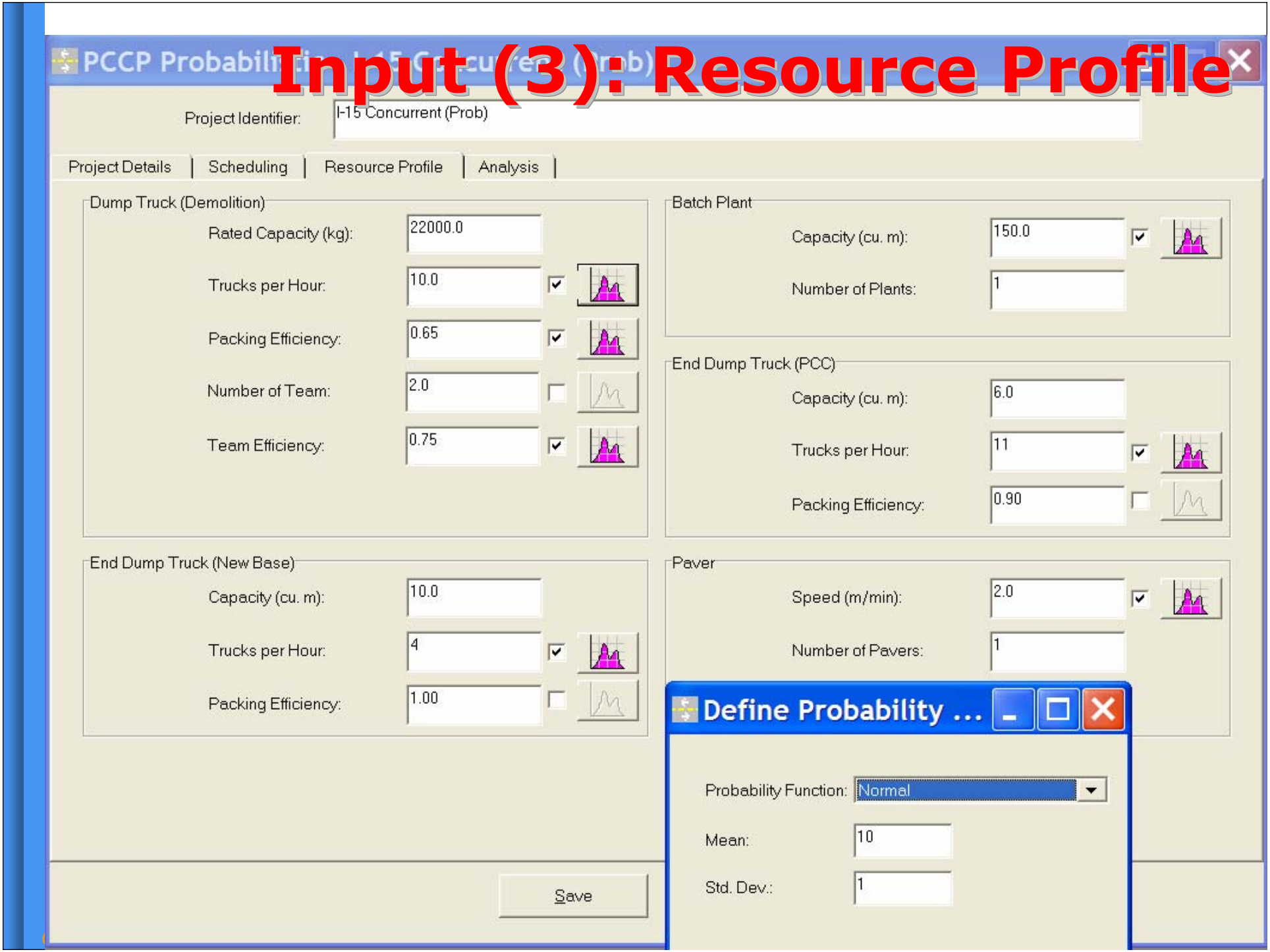

Constructability and Productivity Analysis
Project List in the Database
File
Options
Window
Help
New
Open...
Close
Close All
Open Database...
Backup Database...
Compact Database
Page Setup...
Exit
PCCP Rehabilitation
Full Depth ACP Rehabilitation
CSOL ACP Rehabilitation
Deterministic...
Probabilistic...
Saved Projects
Analysis Type
Project Identifier
Route Name
Analysis Date
Project Description
Deterministic I-15 10-H Nighttime with FSHCC I-15 Devore, San B 3/4/2002 Caltrans District 8 Demonstration Project (Nighttime Closu
Deterministic I-15 72-H Weekday (Final) I-15 Devore, San Be 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Deterministic I-15 72-H DEMO (Back-Up) I-15 Devore, San Be 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Deterministic Workshop Concrete Exercise Interstate-5 9/3/2003 Caltrans District 7
Deterministic I-15 72-H (DEMONSTRATION) I-15 Devore, San Be 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Deterministic I-15 Revised (Concurrent) I-15 Devore, San Be 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Probabilistic I-15 72-H Weekday (Final) I-15 Devore, San B 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Deterministic I-15 Revised (Sequential) I-15 Devore, San Be 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Probabilistic I-15 Devore One-Roadbed Co I-15 Devore, San B 3/18/2003 Caltrans District 8 Concrete Demonstration Project
Deterministic I-710 Phase II I-710 from 405 to F 3/18/2003 Dig Out with PCC
Deterministic I-15 Devore Continuous Closur I-15 Devore, San Be 3/18/2003 Caltrans District 8 I-15 Devore Truck-lane Reconstruction-
Ok
Copy
Delete
Cancel



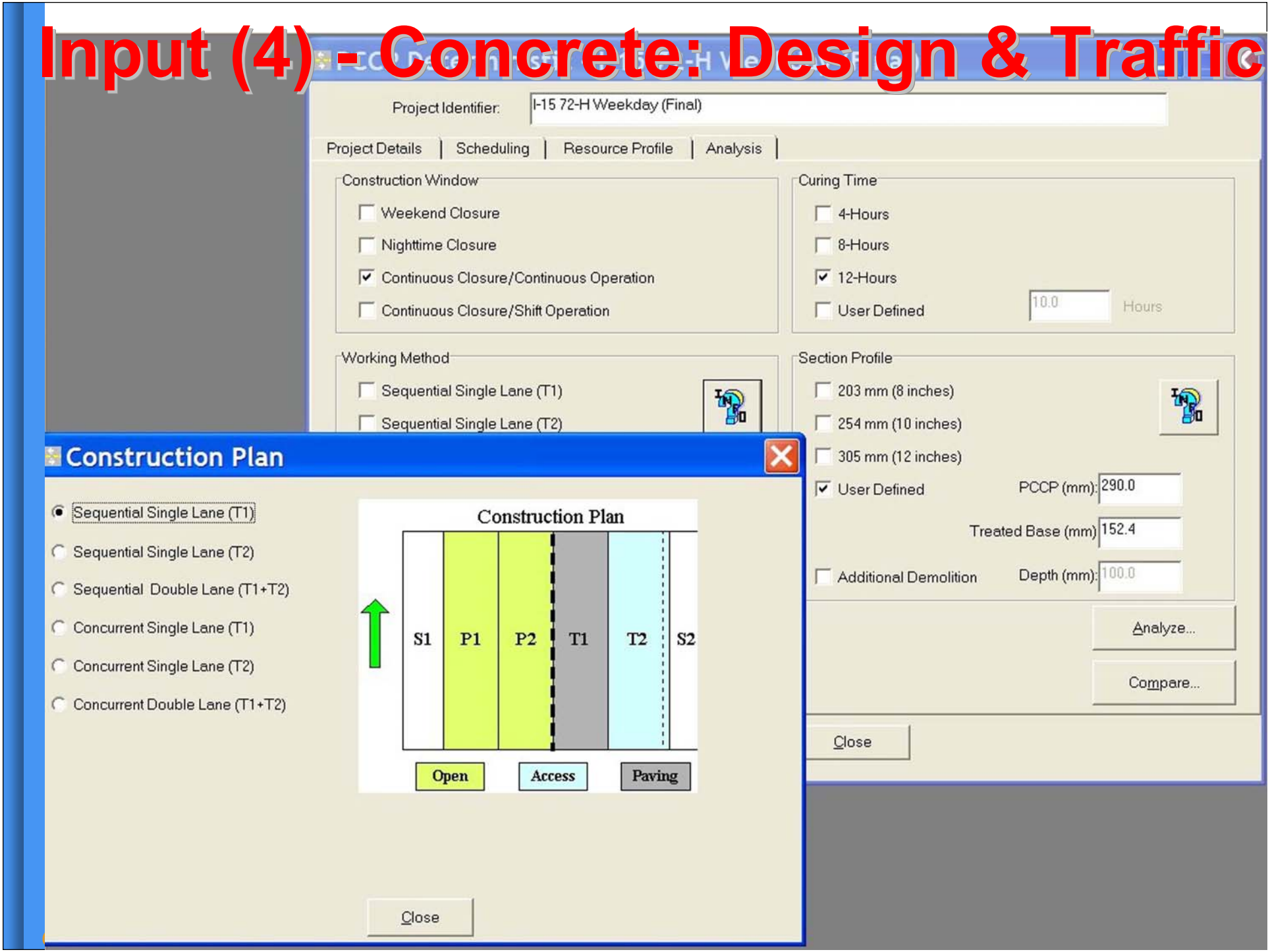
Input (1): Project Details


Constructability and Productivity Analysis
File Options Window
Input (2): Scheduling Interface
PCCP Probabilistic - I-15 72-H Weekday (Final)
Project Identifier:
I-15 72-H Weekday (Final)
Project Details
Scheduling
Resource Profile
Analysis
Mobilization
Mobilization (Hours):
3.0
Demobilization (Hours):
13.7
Construction Start Date:
3 / 1 /2004
Construction Window...
Lag Times for Sequential Working Method
Demolition to New Base Installation (Hours):
14.0
PCCP Installation can begin before New Base Installation is Complete:
New Base Installation to PCCP Installation (Hours):
6.0
Lag Times for Concurrent Working Method
Save
Construction Window Settings
Weekend Closure
Start Time on Friday:
10:00 PM
End Time on Monday:
05:00 AM
Available Hours:
55.0
Nighttime Closure
Start Time on First Day:
07:00 PM
End Time on Next Day:
05:00 AM
Available Hours per Day:
10.0
Continuous Closure/Continuous Operation
Start Time on First Day:
12:00 AM
No. of Continuous Work Days:
3.0
Available Hours per Day:
24.0
Continuous Closure/Shift Operation
Daily Start Time:
06:00 AM
No. of Continuous Work Days:
6.0
Available Hours per Day:
16.0
Save
Close

Input (3): Resource Profile



Input (4) - Concrete: Design & Traffic



Input (4) – Asphalt: Design & Traffic

Project Identifier: 710_Full Depth_55-H Weekend

Project Details | Scheduling | Resource Profile | Analysis

Construction Window
- [x] Weekend Closure
- [ ] Nighttime Closure
- [ ] Continuous Closure/Continuous Operation
- [ ] Continuous Closure/Shift Operation

Working Method
- [x] Single Lane Paving (T1)
- [ ] Single Lane Paving (T2)
- [ ] Double Lane Paving (T1+T2)

Section Profile
- Define... [x] Profile A
- Define... [ ] Profile B
- [x] Additional Demolition Depth 165.0

Cooling Time Analysis
- (•) User Specified
- ( ) MultiCool Computed MultiCool Data...

Lane Widths
- T1 Width (m):
- T2 Width (m):

ACP Layer Definition - Profile A

Lift Number	Lift Thickness (mm)	Lift Name	Lift Cooling Time (hour)	Paver Speed (kph)
4	76.20	PBA-6a	3.00	4.43
3	76.20	AR-8000	3.00	4.51
2	76.20	AR-8000	2.00	4.51
1	94.00	Rich Bottom	1.00	3.36
	Total: 322.60		Average: 2.25	Average: 4.20

Insert | Delete | Ok | Cancel

Multicool for AC Cooling-time Check

ment Cooling Program

Mix Specifications

Number of Lifts 3

Lift Number 1

Next Lift

Mix Type Dense Graded

PG Grade 58 -34

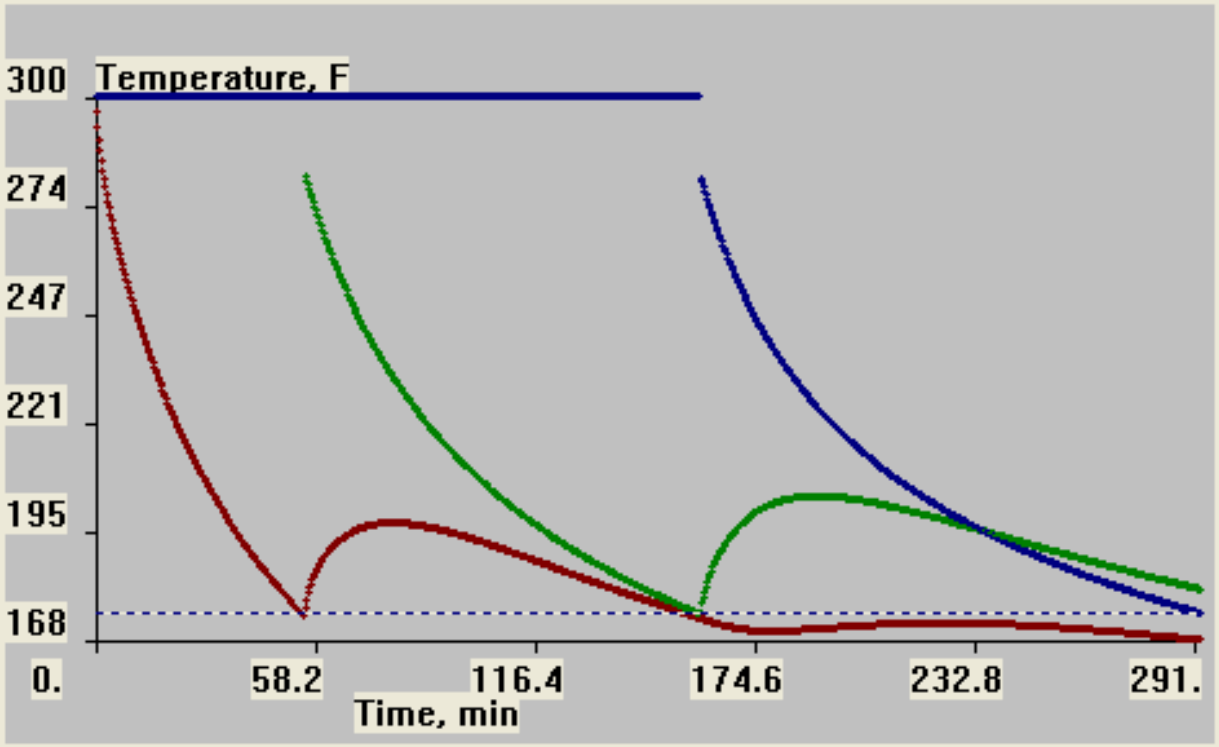
Lift Thickness 3 in.

Delivery Temp 300 F

Stop Temp 175 F

Export Formatted Data

Model Output



Tabular Output

Graphical Output

Deterministic Outputs

Resource Utilization - I-15 72-H Weekday (Final)

Project Identifier:

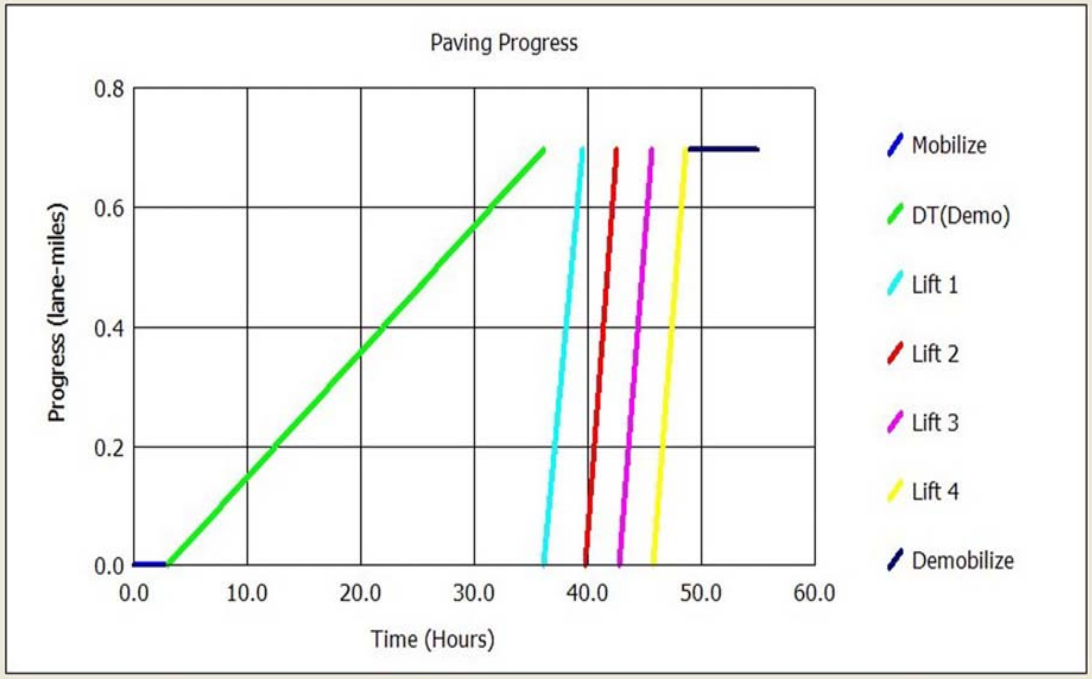
Production Details | Production Chart | Gantt Chart

Construction Window:	**Continuous Closure/Continuous**
Working Method:	**Concurrent Double Lane (T1+T2)**
Section Profile:	**PCCP: 290.0 mm, New Base: 152.4**
Curing Time:	**12-Hours**
Objective (lane-km):	**17.00**
Maximum Possible (lane-km):	**2.56**
Maximum Possible (c/l-km):	**1.28**
Construction Windows Needed	**6.64**
Demolition Quantity (cu. m):	**4485.0**
New Base Quantity (cu. m):	**1545.0**
Concrete Quantity (cu. m):	**2940.0**
Constraint Resource:	
Demolition to Paving:	**N/A**
Demolition Hours:	**35.0**
Paving Hours:	**35.0**

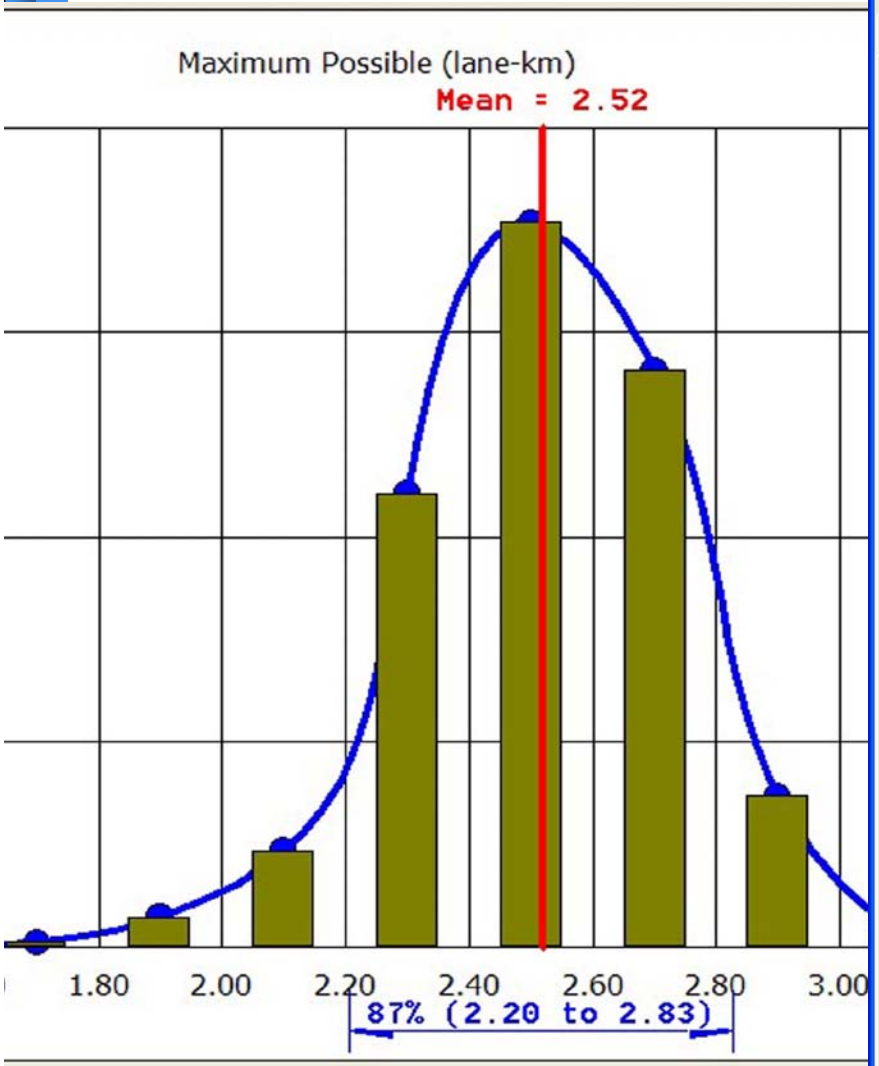
Resource	Allocated	Utilized
Dump Truck (per hour)	10.0	8.4
End Dump Truck (New Base)	8.0	6.3
Batch Plant (cu-m/hour)	150.0	84.0
End Dump Truck (PCC) (per	14.0	14.0
Paver Speed (m/min)	2.0	0.6

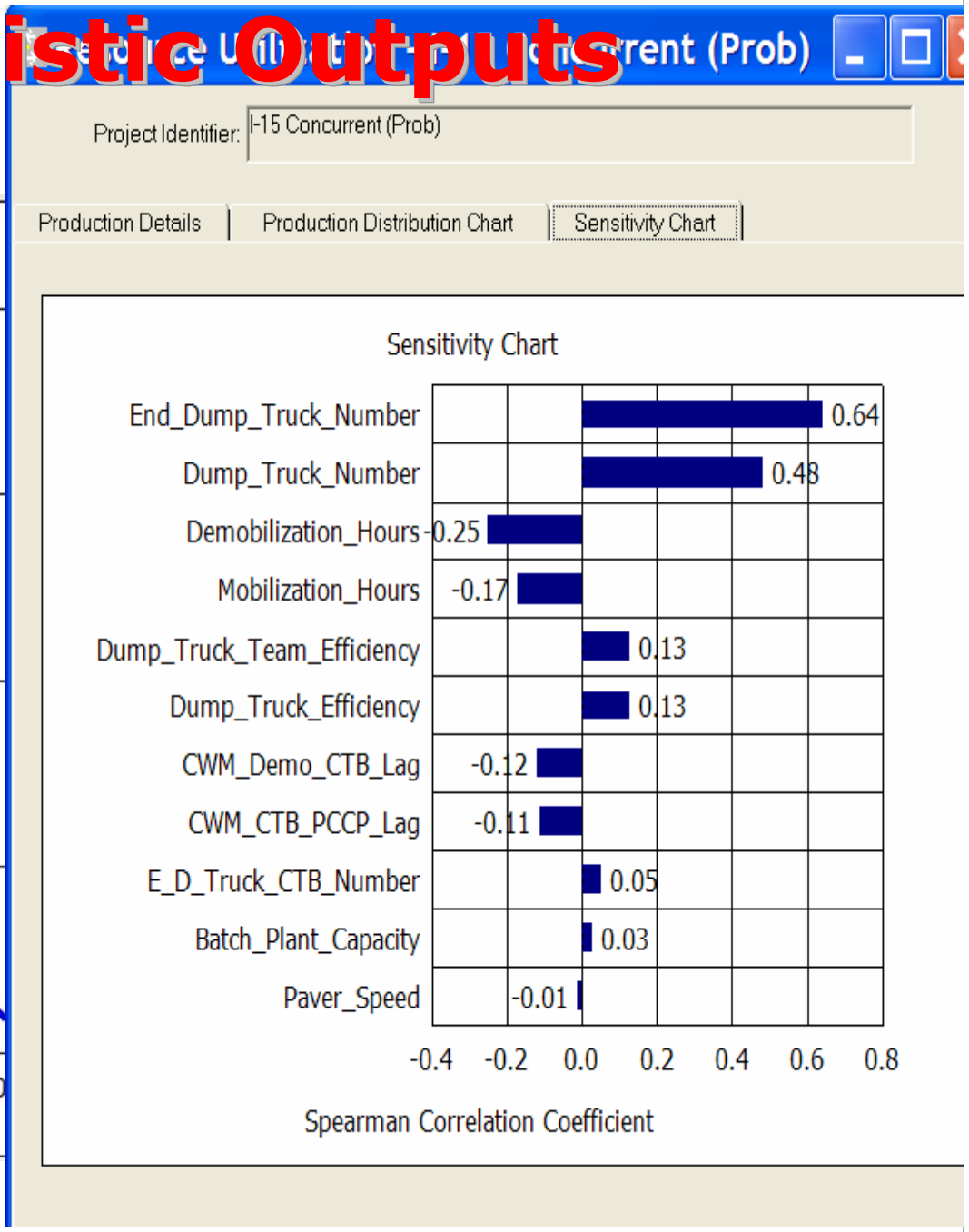
Project Identifier: 710_Full Depth_55-H Weekend

Production Details | Production Chart | Gantt Chart



Probabilistic Outputs





Alternatives Comparison - I-15 72-H (DEMONSTRATION)

Construction Window	Section Profile	Curing Time	Working Method	Maximum Possible (lane-km)	Constraint Resource	Construction Windows	Total Working Hours
Weekend Closure (55 Hours/Weekend)	203 mm (8 inches)	4-Hours	Concurrent Double Lane (T1+T2)	4.84	EDT(New Base),	3.51	193.0
		12-Hours		4.12	EDT(New Base),	4.13	227.1
	305 mm (12 inches)	4-Hours		2.06	DT(Demo)	8.26	454.1
		12-Hours		1.65	DT(Demo)	10.32	567.6
Nighttime Closure (15 Hours/Day)	203 mm (8 inches)	4-Hours		0.00	N/A	N/A	N/A
		12-Hours		0.00	N/A	N/A	N/A
	305 mm (12 inches)	4-Hours		0.00	N/A	N/A	N/A
		12-Hours		0.00	N/A	N/A	N/A
Continuous Closure/Continuous Operation (72 Hours/Closure)	203 mm (8 inches)	4-Hours		6.90	EDT(New Base)	2.46	177.3
		12-Hours		6.18	EDT(New Base),	2.75	198.2
	305 mm (12 inches)	4-Hours		3.23	DT(Demo)	5.27	379.4
		12-Hours		2.81	DT(Demo)	6.04	435.0

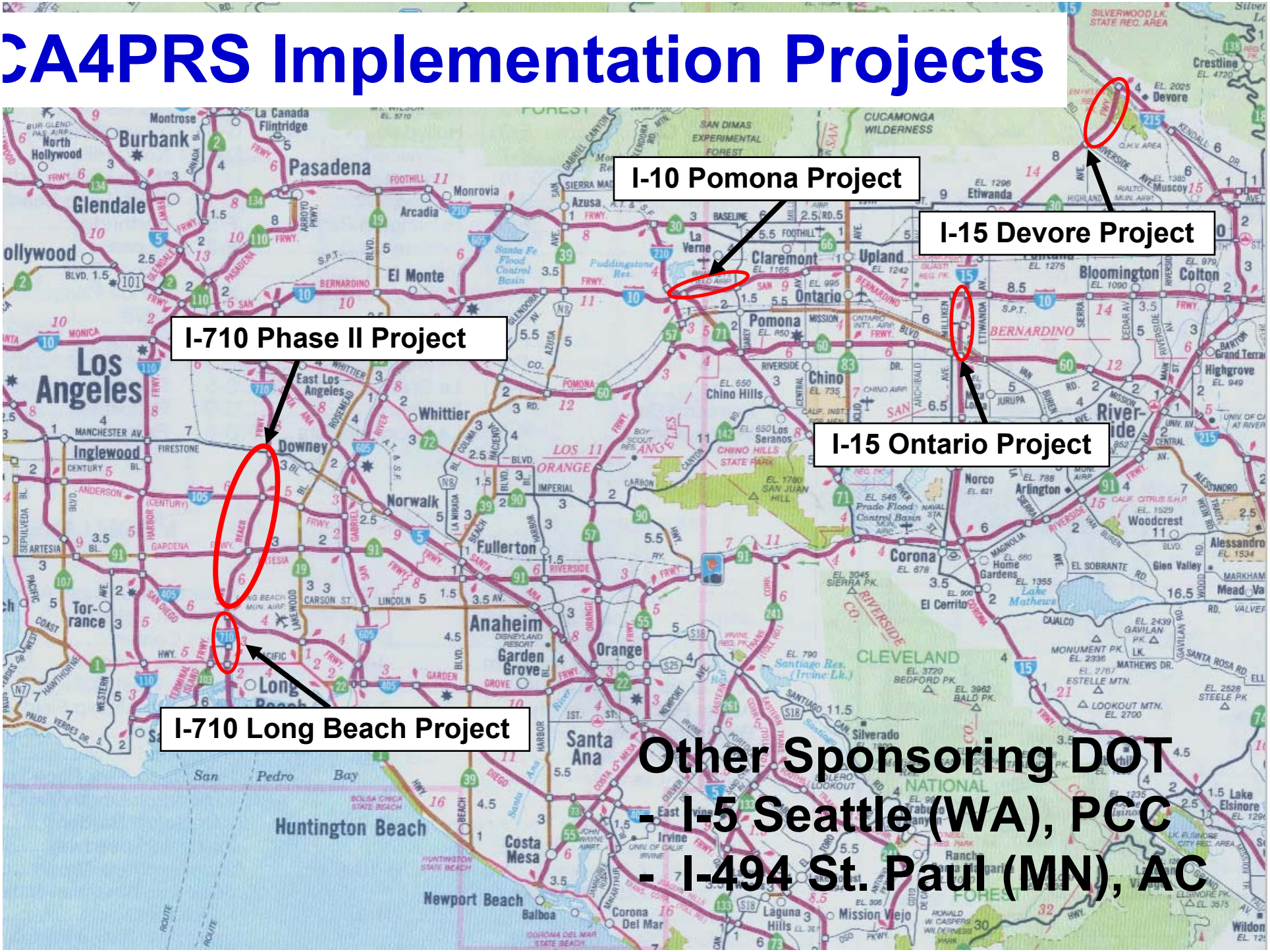
Production Comparison Analysis

Color Coding Legend

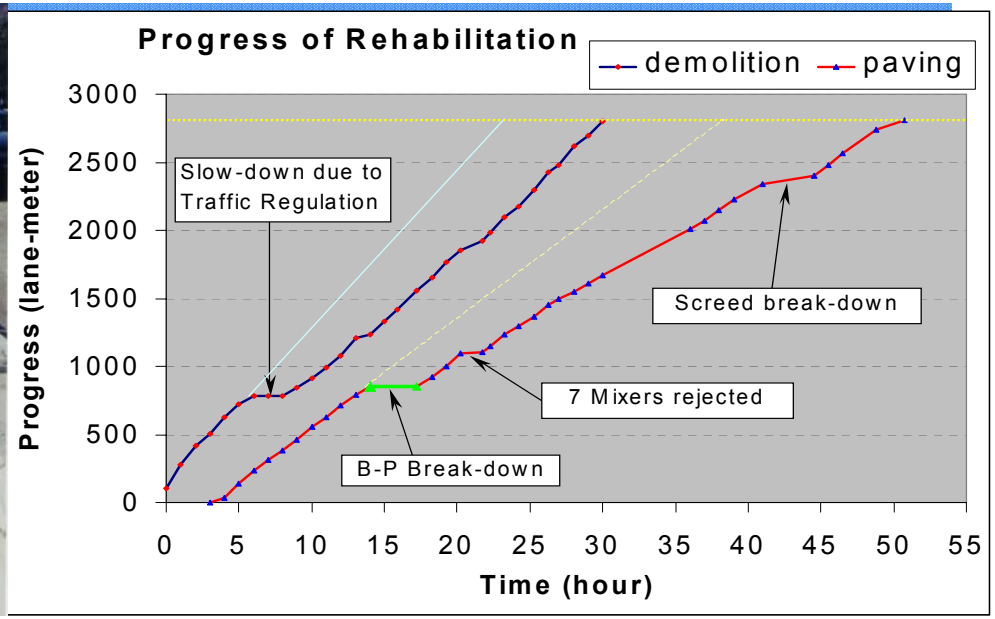
- Objective can be accomplished in one Construction Window
- Objective requires more than one Construction Window
- Not a feasible Construction Window

Implementation (CA, MN, TX, WA)

CA4PRS Implementation Projects



I-10 Pomona Project
CA4PRS Verification

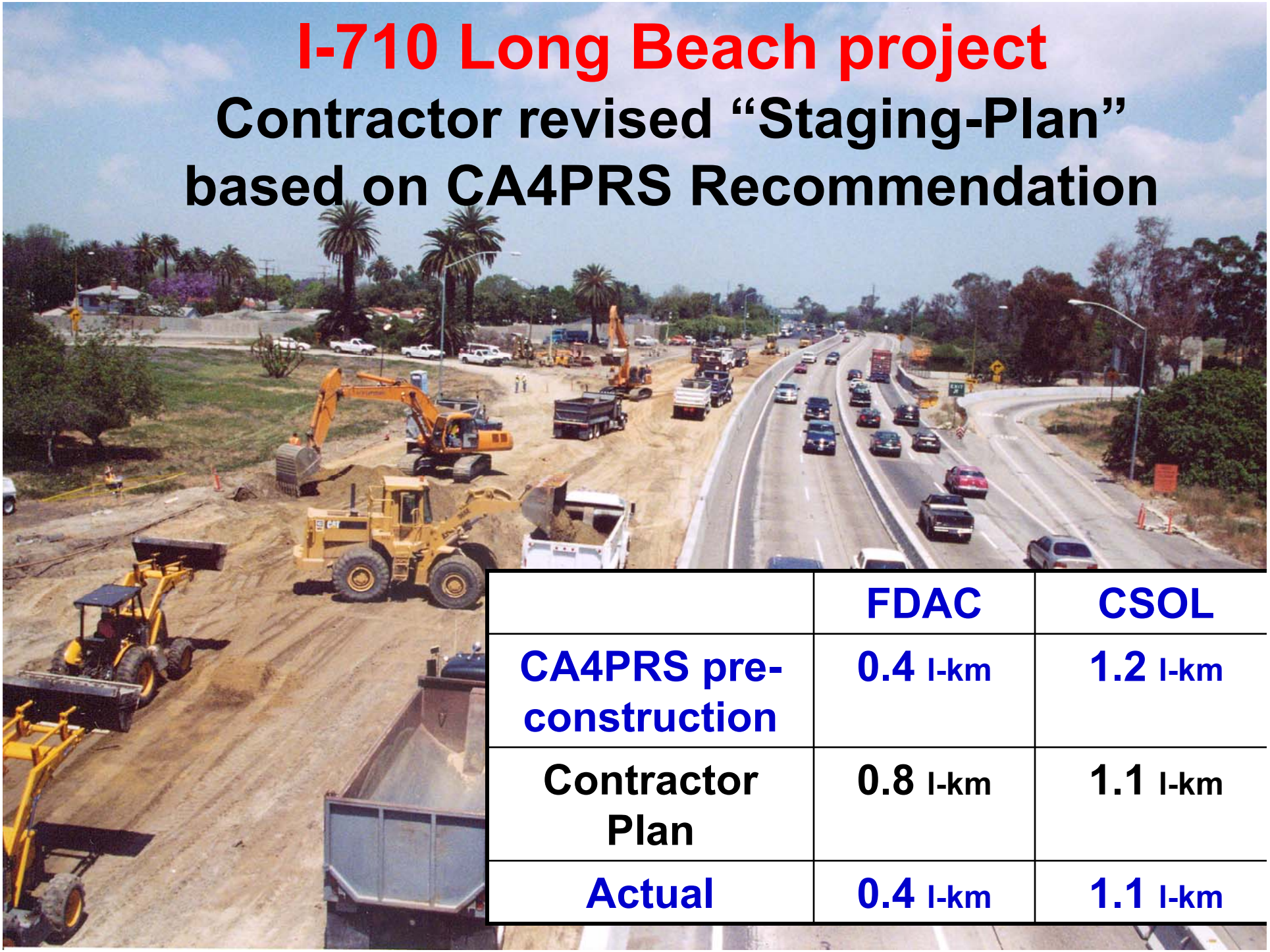


55-hour Weekend Production

- Contractor's Plan = 3.5 lane-km
- CA4PRS Estimate = 2.9 lane-km (2.4-3.4)
- Actual Performance = 2.8 lane-km

I-710 Long Beach project

Contractor revised "Staging-Plan" based on CA4PRS Recommendation



	FDAC	CSOL
CA4PRS pre-construction	0.4 l-km	1.2 l-km
Contractor Plan	0.8 l-km	1.1 l-km
Actual	0.4 l-km	1.1 l-km

I-15 Devore Selected the Most Economical Scenario: Schedule, Traffic Delay, Total Costs

Construction Scenario	Schedule Comparison		Cost Comparison ($M)			Max. Peak Delay (Min)
	Total Closures	Closure Hours	User Delay	Agency Cost	Total Cost	
1 Roadbed Continuous	2	400	5.0	15.0	20.0	80
72-Hour Weekday Continuous	8	512	5.0	16.0	21.0	50
55-Hour Weekend Continuous	10	550	10.0	17.0	27.0	80
10-Hour Night-time Closures	220	2,200	7.0	21.0	28.0	30

Public responses changed 72-hour closures scheme to one-roadbed continuous scenario

EXCELLENCE IN TRANSPORTATION AWARD

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UC Berkeley - ITS

CATEGORY

Transportation Innovations

PROJECT

I-15 Devore Rapid Rehab

2005 EXCELLENCE IN TRANSPORTATION

Certificate of Appreciation

The California Department of Transportation presents this award to:

E.B. Lee

Coming together is a beginning...
Keeping together is progress...
Working together is a Success.

For your cooperation and support of the I-15 Devore Rapid Rehab Project.

ANNE MAYER, District 8 Director

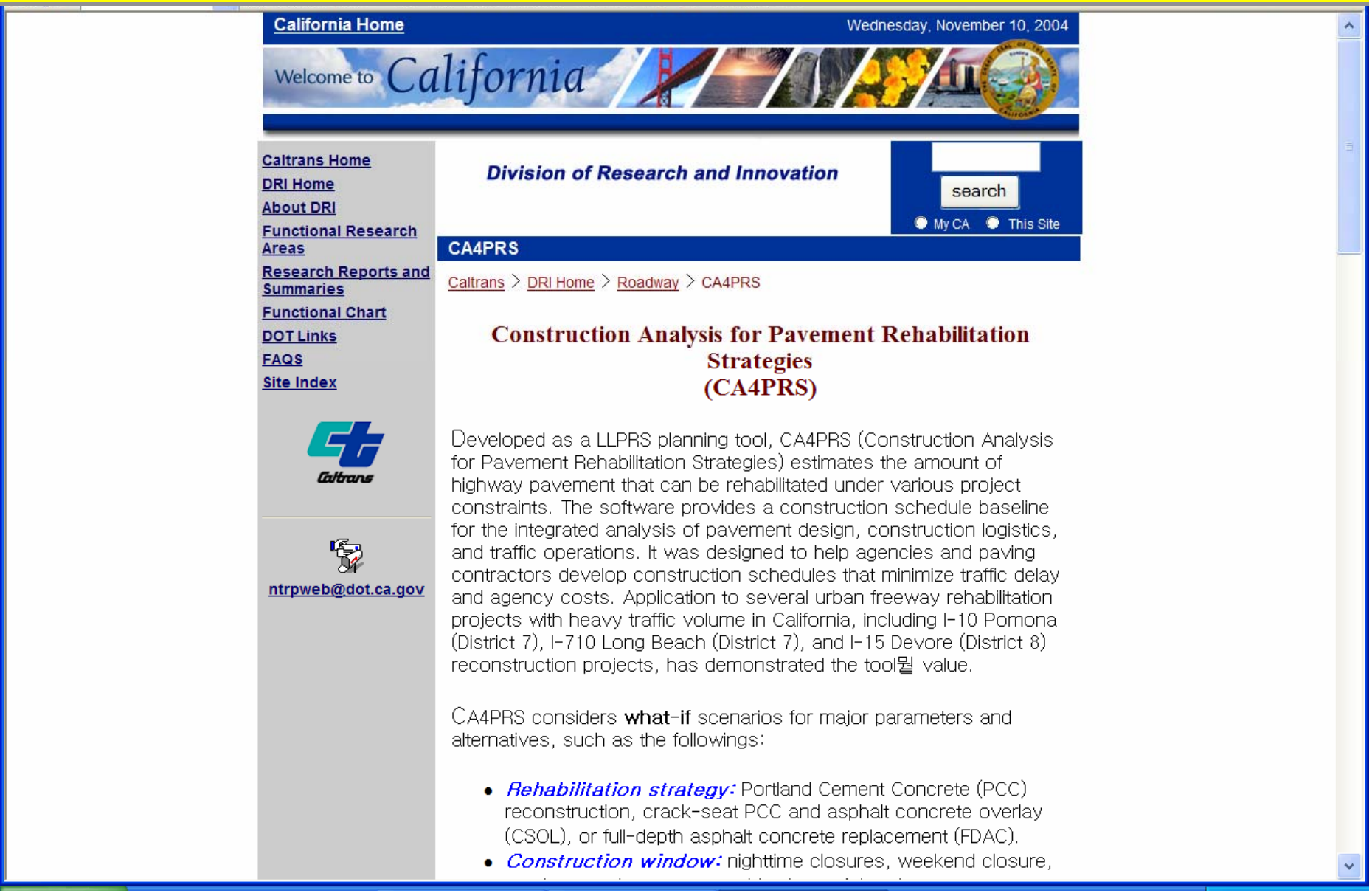
Date

Caltrans

Technology Transfer

http://www.dot.ca.gov/research/roadway/ca4prs/ca4prs.htm

http://onramp.dot.ca.gov/newtech/offices/materials_and_infrastructure/rmi_branch/



Outreach & Tech Transfer

- CAL/APT program to develop prototype
- FHWA pooled-fund to code software
- Validation: CA(I-10, I-710), WA(I-5), and MN(I-94)
- Implementation: D8(I-15 Devore, Ontario), D7(I-710 II)
- HQ Design own and lead
- HQ IT officially approved

➢ Public outreach: Brochure, poster, papers

➢ Training workshops: 500 engineers since 2003

➢ On-line training course in development

➢ Agency (SPTC, LTAP), Industry, Academia

CA4PRS Continuation Enhancement and Upgrade

- V1.0: Basic rehabilitation strategies
  - Separate HCM spreadsheet for delay calculation
- V1.5: Add Rehabilitation Strategies
  - Userability Improve including the User manual
  - CRCP Rehabilitation
- V2.0: Traffic Analysis (Road User Cost)
  - Embed Demand–Capacity Model
  - Economic analysis (RUC + Agency Cost)
- V2.5: Add More Analysis Capability
  - Interchange Improvement and Roadway Widening
- V3.0: Expand to Life Cycle Cost Analysis
  - HQ Design: Pavement Design Guideline Manual

More Information

Caltrans DRI Web
http://www.dot.ca.gov/research/roadway/roadway.htm
UC PRC Web
http://www.pavementresearch.berkeley.edu

Contacts

Caltrans Division of Research and Innovation
Michael Samadian: Contract Monitor
Phone: (916) 324-2048
Email: Michael_M_Samadian@dot.ca.gov

Partnered Pavement Research Center
Dr. E.B. Lee: UC Berkeley ITS
Phone (510) 665-3637
Email: eblee@berkeley.edu
Web: http://www.ce.berkeley/~eblee/